PROCESS CAPABILITY ANALYSIS AT CHAUDRY TEXTILES (MALAYSIA) SDN BHD

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We hereby declare that we have checked this report and in our opinion this report is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

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ABSTRACT

Process capability analysis ensures that processes are fit for industry company specification while reduce the process variation and important in achieving product quality characteristic. Its indices are to measure the inherent variability of a process and thus to reflect its performance. The main objective for this research are to predict current and future capability of the process to produce product within specification in the company and to investigate the product produced by the company meet the customer's specification. This project focuses on Process Capability Analysis that had been applied in small and medium industry in the organization which includes select critical parameters, data collection, study on process capability and data evaluation. This project was successfully done by implementing and applying the capability study to the company.

ABSTRAK

Kebolehan menganalisis sesuatu process adalah untuk membantu sesebuah syarikat industri mengetahui samada proses-proses terbabit yang mengeluar atau menghasilkan produk adalah berada dalam spesifikasi yang ditetapkan. Pada masa yang sama dapat mengurangkan proses variasi dan yang paling penting adalah untuk mencapai karakter produk yang berkualiti dihasilkan. Dalam menentukan sesuatu proses tersebut menghasilkan produk yang baik dan tepat, C_p dan C_{pk} dari kebolehan menganalisis sesuatu proses telah digunakan. Selain itu, C_p dan C_{pk} ini juga dapat membantu sesebuah industri mengetahui proses variasi yang berlaku. Objektif utama projek ini adalah untuk menentukan kebolehan proses menghasilkan produk pada masa sekarang dan kebolehan proses menghasilkan produk pada masa akan datang samada ia mengikuti spesifikasi syarikat industri tersebut atau tidak. Objektif kedua ialah mengenal pasti samada produk yang dihasilkan adalah mengikuti spesifikasi pelanggan atau tidak. Projek ini mengfokuskan kebolehan menganalisis sesuatu proses yang diamalkan dalam organisasi industri kecil dan sederhana yang meliputi pemilihan proses yang paling kritikal, mengumpul data, menganalisis kebolehan proses tersebut dan data penilaian. Projek ini telah berjaya dilaksanakan dan kebolehan menganalisis sesuatu proses telah digunakan oleh syarikat industri tersebut.

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LIST OF SYMBOLS

C_p	Capability index
C_{pk}	Capability index
6σ	6-sigma
USL	Upper specification limit
LSL	Lower specification limit
C_{pu}	Single sided process spread capability index
C_{pl}	Single sided process spread capability index
μ	Process mean
σ^2	Process variance
$\bar{x}_i$	Average of i^{th} subgroup
$\bar{\bar{x}}$	Average of the subgroup averages
$\sigma_{\bar{x}}$	Population standard deviation for the subgroup averages
$\bar{R}$	Average of the ranges
R_i	Individual range value for the sample
A_2	Approximation factor used to calculate control limits
m	Number of subgroups
σ_R	Population standard deviation of the subgroup ranges
D_4	Approximation factor used to calculate range chart
D_3	Approximation factor used to calculate range chart
d_2	Approximation factor for calculating within subgroup
T	Tolerance

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF RESEARCH

Small and medium industry is an enterprise with full-time employees not exceeding 150 or with annual sales turnover not exceeding RM25 million [1]. The definition of Process Capability Analysis is how likely a product is going to meet the design specification. The following scenarios highlight the significance of the process capability studies. Suppose the customers of a major manufacturing company have entered into a contract with the manufacturer regarding the production of some specialty parts. This time, the customers have asked for part tolerances so fine that the company's machine may not be capable of producing to that level of precision. The process capability analysis consists of selecting quality characteristics in the process, collecting data from the process output and calculating process capability indices. The C_p should be at least 1.33 in order for the process to be considered capable. C_{pk} indicates whether it is capable and how well-centered the process is. If the process is not capable, the improvement steps or make an enhancement to the process must be taken by the company [2].

A process capability analysis is made of four things that is the actual process, performance information, action on the process, and action on the output. Using this information, it is possible to determine the proportion of output that will be acceptable. To conduct a process capability study, the following six steps are needed. Firstly, determine the process is in a state of statistical control (via X-Bar and R charts is the most common way to do this). Then, establish the definition of capable (on C_{pk} scale, it is generally > 1). Moreover, establish the process is in control (as defined in the section on control charting). Next on the list, construct a histogram to determine if the process is normal. If the process is normal, continue with the process. After that, determine the mean and standard deviation of the process. Lastly, capability calculations according to the index that is used are to be made [3].

In this case study, Chaudry Textiles (Malaysia) Sdn Bhd had been chosen as a small and medium industry to collaborate in this research which is situated in Pengkalan Chepa, Kelantan. Chaudry Textiles (Malaysia) is actually a manufacturer and marketer of cotton fabric production. The company had produced many products such as cotton, polycotton, polyrayon, polyester staple fibre mixed, unbleached 100% cotton plain weave, unbleached poly cotton plain and unbleached twill polyester [4].

1.2 PROJECT BACKGROUND

Process capability analysis is how well a process meets a set of specification limits. Process capability analysis consists of 3 steps. First step is selecting critical parameters from the process, and then collecting data from the process output last but not least calculating process capability indices (C_p and C_{pk}). If the process is not capable (out of control), the improvement to the process must be taken by the company.

1.3 PROBLEM STATEMENT

The printing process has been selected. There are 4 steps that involved in the printing process. First step the fabric or cotton is taken up by machine and then the fabric goes through the dryer and curing oven. After that the fabric is ready to be printed. Lastly the printed fabric is displayed to the operator and ready to be delivered to the next process. Process capability indices are calculated after the data had been collected.

1.4 PROJECT OBJECTIVES

The objectives have been defined to simplify the main objective of the project. There are:

1. To predict current and future capability of the process to produce product within specification in the company.
2. To investigate the product produced by the company meet the customer's specification.

1.5 PROJECT SCOPE

This project focuses on Process Capability Analysis that had been applied in small and medium industry in the organization which includes:

1. Select Critical Parameters.
2. Data Collection.
3. Study on Process Capability.
4. Data Evaluation.

CHAPTER 2

LITERATURE REVIEW

2.1 RELATED ARTICLES

Based on four summarized articles below, the article with title process capability indices overview and extension is related in this case study. The objective of the article is to analyze the process capability indices that are C_p and C_{pk}. The method that used in this article is capability analysis, operating characteristic function, statistical process control, process performance, specification limits, and target value. From the result of the distributions of capability indices, the product improvement can be continuously monitored. In this article, statistical process control (SPC) and control chart is used to monitor the products quality. For the conclusion, capability indices help to prevent conformance products to be produced which do not meet the specification requirements and help continuously monitor product improvement.

Table 2.1: Summarized of four article

Article/ Author	Year of published	Description of the article
Article- Assessing the process capability index for non-normal processes [5] **Author-** S.E.Ahmed	2004	**Objective-** To propose shrinkage estimation strategies for estimating the population capability indexes. **Method-** Capability index, Non-normal populations, Restricted parameter spaces, Stein-type estimation, Asymptotic risk analysis. **Result-** If the scale distance between the actual value of the true parameter and the guessed value is large, the behavior of the both shrinkage estimators is the same, which supports the validity of our asymptotic theory as well. **Conclusion-** Stein-type shrinkage estimator (SE) and positive-part shrinkage estimator (PSE) are the best method and should be used as a tool for developing the positive part shrinkage estimator.

Article- C_{pk} index estimation using fuzzy numbers [6] **Author-** Hong Tau Lee	2001	**Objective-** To propose a method to calculate the C_{pk} index when precise quality cannot be identified and must referred to the decision-makers subjective evaluation of the quality of product. **Method-** Fuzzy theory [13, 14, 15 and 16] is applied to construct the PCI. Fuzzy set theory, as developed by Zadeh [13, 14 and 15], and the concept and arrangement of fuzzy numbers presented by Dubois and Prade [4, 5, 6 and 7] are applied to improve the presentation of the fuzzily defined system. **Result-** Although, the calculation is a little tedious, however, with a formula it can be easily calculated by a computer. The larger value of $U_{T(G)}$ indicates that the mean of quality measurement of the sample is closer to the target of specification and the quality of the sample is more coincident and stable. **Conclusion-** The exposition approach proposed in this journal is generic enough to be applicable to the fuzzy number with other types of membership functions.

Article- Process capability indices overview and extensions [7] **Author-** Zachary G.Stoumbos	2001	**Objective-** To analyze the process capability indices. **Method-** Capability analysis, Operating characteristic function, Statistical process control, Process performance, Specification limits, Target value. **Result-** Products improvement can be continuously monitored in the distributions of capability indices. **Conclusion-** Capability indices help to prevent conformance products to be produce
Article- Process capability indices and product reliability [8] **Author-** Bharatwaj Ramakrishnan,	2001	**Objective-** To discuss the relationships between process capability indices and product reliability. **Method-** Process capability indices C_p and C_{pk}. **Result-** C_p does not take the process mean into account and does not reflect the non-conformance rejects, or reliability.

Peter Sandborn and Michael Pecht		**Conclusion-** There are many product characteristics, which contribute to product quality or reliability. By obtaining a higher C_{pk} for that process can improve the quality and reliability.

2.2 PROCESS CAPABILITY INDICES

Statistical methods are becoming more popular in industrial quality control. They are widely used to understand the natural variation in the industrial processes and help managers to make intelligent decisions. Focusing on process variation and for improvement purposes, process capability indices have been used excessively in the field of quality control. The purpose of these indices is to determine whether the manufacturing process is capable of producing final products which are within the customer specifications, often called design tolerances. The most common indices being applied by manufacturing industry are C_p and C_{pk}. C_p is the process capability ratio and is defined as follows:

$$C_p = \frac{Allowable\ process\ spread}{Actual\ process\ spread} \tag{1}$$

Figure 2.1: Equation of C_p

C_p= Process capability index that indicates process potential performance relating to the specification spread

Allowable process spread= (USL-LSL)

Actual process spread= 6σ

This can be also expressed as follows:

$$C_p = \frac{USL - LSL}{6\sigma} \qquad (2)$$

Figure 2.2: Equation of C_p with upper and lower specification and process standard deviation

USL= Upper specification limit σ= Process standard deviation
LSL= Lower specification limit

C_p is the process capability ratio for off-center processes and is defined as the minimum value of one-sided upper or lower process capability ratios. If cp is greater than or equal to 1.0, the process would produce conforming parts. A cp value of less than 1.0 means the process would produce some nonconforming output. The greater this value, the better.

$$C_{pk} = Min\{C_{pu}, C_{pl}\} \qquad (3)$$

Figure 2.3: Equation of C_{pk}

C_{pk}= Process capability index that indicates process actual performance by accounting for
shift in the mean of the process within the upper and lower specification limit

C_p cannot be used without both Upper and Lower Specifications Limits. Cp does not account for process entering. If the process average is not exactly centered in nominal, the Cp index will give misleading results. If the process is not centered, a better measure of actual capability is Cpk. One sided capability measures are as follows:

$$C_{pu} = \frac{USL - \mu}{3\sigma}, \; C_{pl} = \frac{\mu - LSL}{3\sigma} \tag{4}$$

Figure 2.4: Equation of C_{pk} with upper and lower and two-sided specification limit

C_{pu}= C_{pk} for upper specification limit

C_{pl}= C_{pk} for lower specification limit

In the above equations, *USL* and *LSL* are the upper and lower design specification limits, μ and σ are the process mean and standard deviation respectively [10]. Since the process mean μ and process variance σ^2 are unknown, they are often estimated using collected data [11]. Note that Cp and C_{pk} are applied to determine the process capability with bilateral specifications whereas C_{pu} and C_{pl} are applied to unilateral specifications.

In effect, C_{pk} is a one-sided process capability ratio that is calculated relative to the specification limit nearest to the process mean. The estimate of the process capability ratio, C_{pk}, is:

$$C_{pk} = \text{Min}\left[\frac{USL - \overline{X}}{3\hat{\sigma}}, \frac{\overline{X} - LSL}{3\hat{\sigma}}\right] \tag{5}$$

Figure 2.5: C_{pk} with one-sided specification limit

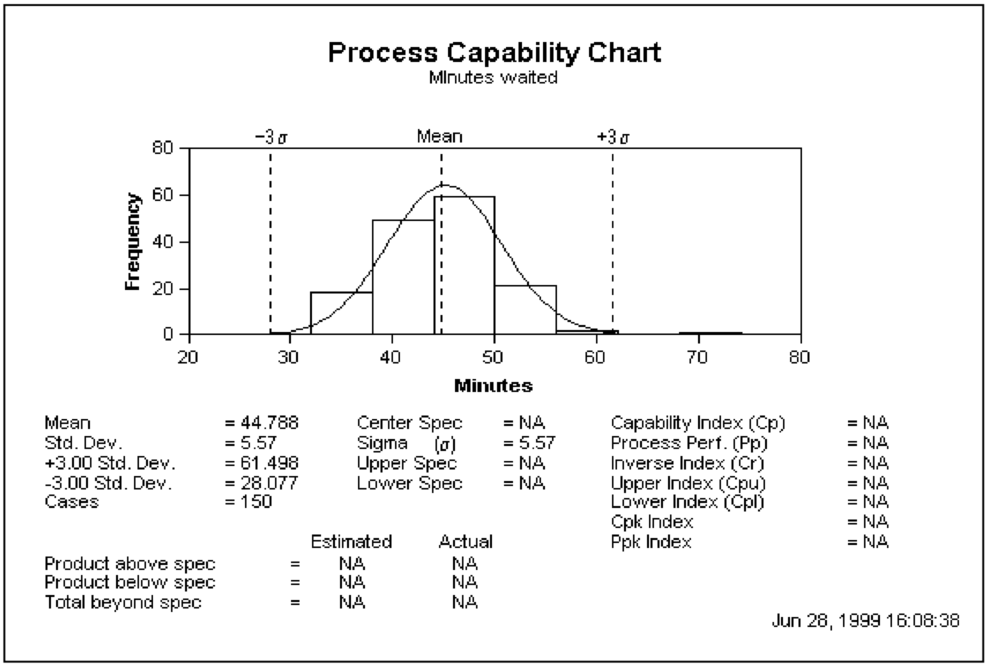

Figure 2.6: Example of process capability chart

Table 2.2: Equivalent C_p value and capability to produce nonconformance product

Equivalent, C_p value	Capability to produce nonconformance product, %
0.50	86.64
0.62	93.50
0.68	96.00
0.81	98.50
0.86	99.00
1.00	99.73
1.33	99.994

Table 2.3: Equivalent C_{pk} value, quality level and DPMO [12]

Equivalent, C_{pk} value	Quality level	Defects per one million opportunities (DPMO)
1.00	3	2700
1.33	4	63
1.66	5	0.57
2.00	6	0.002

Small and medium industry used value of C_p=1.33 as a minimum acceptable target. Some companies require that internal processes and those at suppliers achieve a C_p = 2.0. A process with C_{pk} = 2.0 is referred to as a Six Sigma process because the distance from the process mean to the nearest specification is six standard deviations. In the Six Sigma process, if the process means shifts off-center by 1.5 standard deviations, the Cpk decreases to $4.5\sigma/3\ \sigma = 1.5$. Assuming a normally distributed process, the fallout of the shifted process is 3.4 parts per million. Consequently, even when the mean of a Six Sigma process shifts by 1.5 standard deviations from the center of the specification, it can still maintain fallout of 3.4 parts per million opportunities [9].

2.3 SIX SIGMA VERSUS THREE SIGMA

The traditional quality model of process capability differed from Six Sigma in two fundamental respects:

1. It was applied only to manufacturing processes, while Six Sigma is applied to all important business processes.